

SIGNIFICANCE OF ELEVATED K/Rb RATIOS IN LOWER CRUSTAL ROCKS

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Lower crustal rocks with granulite mineralogies commonly have K/Rb ratios that range up to 2000 (see field enclosed by dashed lines, Fig. 1), many times that found in most volcanic rocks. These high ratios have been interpreted by many authors as having been produced by massive influx of H₂O-poor fluids that preferentially removed Rb during breakdown of biotite and hornblende^{1,2}. The same Rb depletion may also be produced by simple dehydration³. Consequently, high K/Rb ratios in granulite facies rocks are often used as evidence that the granulite metamorphism leads to extensive metamorphic differentiation of the lower crust^{1,4-7}. It is our contention that high K/Rb ratios may form by igneous processes as well as from metamorphic ones and that the presence of granulites with high K/Rb ratios in no way implies that granulite metamorphism necessarily leads to depletion of rocks in LIL elements.

Granulitic rocks with high K/Rb ratios have one common characteristic: they also have less than 1.5% K₂O. Such low-potassium rocks rarely contain a separate potassium feldspar phase; the small amount of potassium present can be accommodated in plagioclase. For example, experimental results⁸ indicate that a plagioclase with Ab/An = 0.70 can accommodate 2.3% K₂O at 825°C and 1 kilobar, and thermodynamic modelling⁹ indicates that solubility of K₂O will increase in plagioclase with increasing pressure. Thus a granulite containing 70% plagioclase metamorphosed at 825°C can accommodate 1.7% K₂O in the plagioclase without contributions from any other phase.

Crucial to the understanding of Rb behavior during lower crustal igneous processes is the concept that a silicic magma emplaced under granulite conditions will not be able to cool to the H₂O-saturated solidus. Rather it would be expected to crystallize pyroxene-bearing cumulates while a more hydrous and evolved melt moves to higher crustal levels¹⁰. Thus many pyroxene-bearing rocks may be cumulates, rather than direct representatives of a melt. Although available Kd data for melt-crystal fractionation are highly variable, they do indicate that Rb is strongly incompatible with plagioclase, while K is more compatible¹¹. Plagioclase phenocrysts from volcanic rocks have K/Rb ratios ranging from 440 to more than 4000, with the

lower values found in more anorthitic plagioclase¹². This indicates that a cumulate consisting of plagioclase and pyroxene, with or without quartz, forming from a melt with normal K/Rb can have K/Rb ratios as high as those found in granulite terranes (see ref. 13). In rocks where orthoclase is a crystallizing phase, however, Rb becomes far more compatible¹⁴ and Rb depletion does not accompany formation of cumulates.

As can be seen in Figure 1, K/Rb ratios for unmetamorphosed, plagioclase-pyroxene cumulates, involving both anorthosites and dioritic rocks, from both the Laramie¹⁵ and Nain Complexes¹⁶ have precisely the same trends as seen in granulite terranes. In both the K/Rb ratio increases with decreasing K content. Furthermore, these indisputably igneous rocks also have the very low Rb/Sr ratios previously attributed to granulites². It is evident, therefore, that rocks strongly depleted in LIL elements may form by cumulate processes as well as by metamorphic processes. Thus the depleted geochemical signature which is commonly distinctive of granulite facies provides no real constraint on the processes by which these rocks formed. Rather, detailed geologic mapping of each terrane is required to determine whether the geochemical signature is the result of igneous or metamorphic processes.

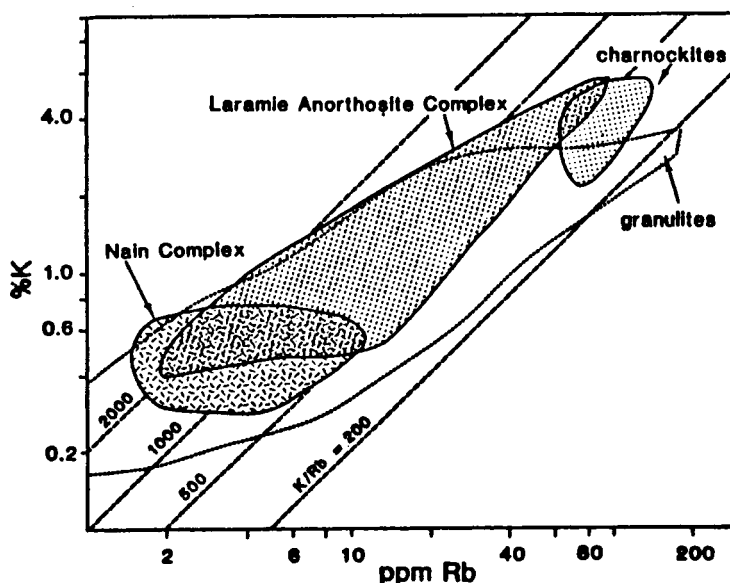


Figure 1: Comparison of K/Rb ratios for granulites (dashed line), charnockites, and cumulates from the Nain and Laramie anorthosite complexes. Data from 15 - 19.

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